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ABSTRACT

During 12 years of investigation, data were obtained from 2,500 high school students and 10,000 college students concerning the effect of specific types of visualizations in producing optimum levels of achievement. The studies considered such qualities of illustrations as: realism, color, relation to oral presentations, relation to educational objectives, interaction time. Specially designed criterion tests were developed to measure: drawing, identification, terminology, and comprehension. The results showed that visuals do not necessarily enhance learning. When visuals are effective, the amount learned depends on such factors as the medium through which the visual was presented, its relation to the educational objective, and the time of interaction. (ASH)

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PRACTICAL CONSIDERATIONS IN USING VISUALIZED MATERIALS IN THE INSTRUCTIONAL DEVELOPMENT PROCESS

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PRACTICAL CONSIDERATIONS IN USING VISUALIZED MATERIALS IN THE INSTRUCTIONAL DEVELOPMENT PROCESS

OBJECTIVE: To familiarize instructional developers with research results obtained from a 12 year program of evaluation (over sixty completed studies) designed to identify specific types of visualization most effective in producing optimum levels of student achievement of different types of educational objectives.

PRESENTATION DESCRIPTION: The presentation will emphasize the interrelationship which exists among the different types of visual materials, different types of educational objectives, different methods of presentation, different cueing techniques, etc. Studies describing the results obtained from evaluations involving television, slide/audiotape, programmed instruction, and textbook formats will be reviewed.

GENERAL ORIENTATION FOR EMPIRICAL INVESTIGATION

If guidelines are to be developed which will facilitate the effective and efficient use of visual illustrations for instructional purposes, then further research needs to be conducted on the instructional potential inherent within different types of illustrations. In order to implement such an investigation, the following questions were developed to provide a general orientation for a program of systematic evaluation.

1. Is the realism continuum for visual illustrations an appropriate and reliable predictor of instructional effectiveness when it is used to complement oral and printed instruction, or are there points on the realism continuum at which further increases of realism in visual illustrations fail to produce significant differences in student achievement of specific educational objectives?

2. Will the use of visual illustrations that are specifically designed to complement oral and printed instruction automatically improve student achievement?

3. Are identical types of visual illustrations equally effective in complementing both oral and printed instruction?

4. Are all types of visual illustrations equally effective in facilitating student achievement of all types of educational objectives?

5. Is color in visuals an important instructional variable in facilitating student achievement of specific objectives?

6. Will the use of visuals to complement oral instruction affect delayed retention of the content material?

7. Are student perceptions of the value of different types of visual illustrations a valid assessment of the instructional effectiveness of the visuals?

8. Does the method in which visuals are presented to students affect the ability of the visuals to facilitate achievement of different educational objectives?

9. Does the amount of time students are permitted to interact with visualized instruction affect their level of achievement of different educational objectives?

10. Are identical types of visual illustrations equally effective for all education levels (i.e., 9th, 10th, 11th, 12th, and college), or do the different types of visual illustrations possess differing degrees of instructional effectiveness for all students at different educational levels and for different educational objectives?

11. Are different cueing techniques (motion, inserted questions, knowledge of specific learning objectives) equally effective in complementing visualized instruction?

12. Can oral and printed questions be used to improve the instructional effectiveness of visualized instruction?

13. Do boys and girls in the same grade level (high school) learn equally well from the same types of visual illustrations on tests designed to measure achievement of different educational objectives?

14. Is there only one visual learning continuum representing instructional effectiveness of visuals for complementing both oral and printed instruction?

15. Can student achievement of different educational objectives be improved by increasing the size of the visual illustrations that are used to complement oral instruction?

16. How does a student's entering behavior (prior knowledge in a content area) influence his ability to profit from visualized instruction?

GENERALIZABILITY OF RESULTS

Some of the criticisms currently being leveled at media research are:

1. The content material being presented experimentally is restricted in that it is far removed from that which is currently being taught in schools; consequently, the results have had little practical importance;

2. Criterion tests used to measure student achievement are global, rather than designed to measure achievement of specific educational objectives;

3. The visualization used has not been specifically designed to complement the content material;

4. The amount of time students have been permitted to view and interact with the instructional presentations has not been adequately controlled;

5. The type of visualization used (that is, the amount of realistic detail contained in the visualization) has not been described adequately;

6. The method of presenting the visualization has not been described precisely, and in many cases the content material which was presented by one method (for example, slides, film) has not been equivalent to the content material presented by a second method.

Deficiencies identified in prior media research were controlled in the series of studies summarized in this report. In order to enhance the generalizability of the results a 2,000-word instructional unit was developed describing the human heart, its parts, and the internal processes occurring during the systolic and diastolic phases. This script constituted the subject content presented to students participating in each of the studies. In some studies the content was presented orally; in other studies it was presented via the printed channel (programmed or textbook-like booklets). The types of visualization used to complement the oral and verbal instruction remained constant throughout all the studies.

Several criterion tests were designed to measure student attainment of different educational objectives, each of which required a specific type of learning. By employing these criterion measures, a more comprehensive understanding may be realized of the true effect that variations in realistic stimuli have on student achievement of different educational objectives. The Kuder-Richardson Formula 20 reliability coefficient for the five criterion measures was computed for each study. The obtained coefficients were generally consistent across studies. Average reliability coefficients for each criterion measure were derived from a random sampling of the studies, that is: .81-drawing test, .70-identification test, .82-terminology test, .76-comprehension test, and .91-total criterion test.

PREPARATION OF MATERIALS

The 2,000-word instructional unit on the human heart was analyzed to identify those areas in the instruction where critical information was being presented--areas where it might reasonably be expected that students would experience difficulty in comprehending the information. Thirty-nine such areas were identified. Visuals were designed specifically to illustrate the information in each of the criterion areas. Eight complete visual sequences were designed and reproduced as 2 x 2-inch slides; four sequences were in black and white, and four were in color.

The heart model and realistic photographic treatments were obtained from photographs taken professionally of a heart model and actual heart specimens, respectively. A veterinary surgeon performed the cuttings on the hearts so that photographs depicting the desired concepts could be obtained. From the sequence of realistic photographs, a graphic artist produced the line presentations and the detailed, shaded drawings, both black and white and colored versions. The heart model photographs in black and white and color were included in the evaluation because they represent the types of visual illustrations currently being included in modern textbooks. They also possessed more realistic detail than the detailed, shaded drawing presentations. Care was taken to make certain that the same format and size relationships that appeared in the original heart photographs were conveyed to the drawings, and eventually to the slide sequences. Printed symbols were used in each illustration to facilitate the correct spelling of the terminology being presented and to enable students to differentiate between those parts of the heart in which pronunciation and spelling are almost identical. The same set of printed symbols was used in all experimental treatments, and they were positioned in identical locations in each illustration.

Arrows were used in the visual illustrations to focus students' attention on the particular part or location of the heart being emphasized in the instruction. The shape, length, and position of the arrows in similar illustrations for the various visualized treatments were identical. Both black and white arrows were used in the illustrations; white arrows were used in those slides where black arrows would have blended into the background.

CRITERION MEASURES

In order to determine what types of visuals are most effective in facilitating student achievement of specific educational objectives, four individual criterion measures were developed. The tests were administered in the following order: drawing, identification, terminology, and comprehension. In each study each student was permitted to take as much time as he required to complete on criterion measure before proceeding to the next. A description of the criterion measures follows.

Drawing Test. The drawing test (18 items) provided the students with a list of specific terms corresponding to the parts of the heart discussed in the instructional unit. The students were required to draw a representative diagram of the heart and place the numbers of the listed parts in their respective positions. For this test the emphasis was on the positioning of the verbal symbols with respect to their concrete referents, not on the quality of the drawing. This test evaluated student learning of specific locations of the parts of the heart. Knowledge of positions, recall of patterns, structures, or settings of parts within an entity could be included in a test of this nature.

Identification Test. This multiple-choice test (20 items) required students to identify the numbered parts on a detailed drawing of a heart. Each part of the heart that had been discussed in the instruction was numbered on the drawing and appeared in a list on the answer sheet. Students were required to look at the detailed drawing and select the appropriate identifying response in each multiple-choice item. The objective of this test was to measure the student's ability to identify parts of the heart from information received in the instruction.

Terminology Test. Initially, this test (20 items) consisted of a series of fill-in questions in which one answer only was correct. For later studies it was changed into a multiple-choice format to facilitate scoring. This test evaluated student knowledge of referents for specific symbols.

Comprehension Test. The comprehension test consisted of 20 multiple-choice items. Given the location of certain parts of the heart at a particular moment of its functioning, the student was asked to locate the position of other specified parts of the heart. This test required that the student have a thorough understanding of the heart, its parts, its internal functioning, and the simultaneous processes occurring during the systolic and diastolic phases. The comprehension test was designed to measure a type of learning that occurs when the individual understands what is being communicated and can use the information to explain some other phenomenon.

Total Criterion Test. The items contained in the four individual criterion tests were combined into a 78-item total criterion test. The purpose of this evaluation was to measure the student's total understanding of the information.

It should be noted that in this investigation the type of learning measured by the different tests is the important aspect, rather than the heart content per se. The learning objectives have generalizability in that they may be appropriate in all content areas. For example, (a) the objectives measured by the drawing test could be applied to students in a geography class who are learning the location of the fifty states, or to students in a mechanics course learning the relative locations of the various parts of a carburetor; (b) tests similar to the identification test could be used in any course in which the student is required to know the various parts of objects (for example, in a physiology course to

indicate the parts of the human body, or in a botany course to name the parts of differnt types of plants); (c) the objectives of the terminology test--to evaluate student knowledge of specific verbal symbols--is appropriate to any content area; and (d) tests similar to the comprehension test can be used in any subject area in which the objective is to measure the student's understanding of complex procedures and processes.

TREATMENT GROUPS

The visualized treatmens were considered to be the experimental groups; the group receiving illustrations on which appeared only printed symbols of the terms being discussed in the instructional presentation was the control group. The amount of realistic detail possessed by the visual illustrations was varied for each of the visualized treatments; however, all treatment groups received identical instructional content. The instructional treatments were:

Oral/Verbal Presentation. Students in the oral/verbal presentation received no visuals of the heart but viewed displays containing the names of the parts and processes of the heart as they were mentioned in the instructional presentation.

Simple Line Drawing Presentation (B&W). Students in the simple line drawing presentation (b&w) viewed simple line illustrations depicting the form and the relative locations of the parts of the heart as they were mentioned in the instruction. The line drawings used in this presentation were similar to instructional drawings used in many current science textbooks.

Simple Line Drawing Presentation (Color). Students in this group viewed simple line illustrations in color to complement their instruction. The colors used in this treatment, blue lines on a pink background, were selected solely to provide color contrast and were not designed in any way to provide additional learning cues for the students. The color used in the three additional colored treatments did not intentionally provide more information than did their complements, the black and white treatments. However, the use of color in some instances may have facilitated more rapid identification of specific parts and the related systems of the heart.

Detailed, Shaded Drawing Presentation (B&W). Students in this group viewed detailed, shaded drawings to complement their instruction. These drawings were more complex than the simple line drawings, and they represented the heart and its related parts realistically, rather than merely identifying and locating them as in the line drawings.

Detailed, Shaded Drawing Presentation (Color). Students in the detailed, shaded drawing presentation (color) viewed illustrations similar to those in the previous group, except that they were colored.

Heart Model Presentation (B&W). Students in this group viewed black and white photographs of a heart model while the heart and its related parts were being described in the instruction.

Heart Model Presentation (Color). Students in the heart model presentation (color) viewed colored photographs of a heart model.

Realistic Photographic Presentation (B&W). Students in this group viewed black and white realistic photographs of the heart.

Realistic Photographic Presentation (Color). Students in the final group viewed colored realistic photographs of the heart.

EXPERIMENTAL PROCEDURE

The sample population involved in the studies summarized in this report represents 2,500 high school (ninth, tenth, eleventh, and twelfth) and 10,000 college level students. In each study, each student received a pretest, participated in his respective instructional treatment, and received four individual criterion tests. Two different pretest were used at different times throughout the series of studies. They were: (1) a physiology pretest, used to measure the student's prior knowledge in the specific content area; and (2) the Otis Quick-Scoring Mental Ability Test (Form Fm), which provided an IQ score. Although randomization of students to treatment groups was effected in a majority of the studies, it was not possible to implement this technique in all studies (that is, the studies using high school students). However, all students, including those randomly assigned to treatment groups, received a pretest. Scores achieved on the pretest measures were analyzed, and when significant differences occurred among treatment groups, these scores were used as a covariate to partial out their effect. Analysis of variance and covariance (where significant differences occurred on the pretest measures) were used throughout the cited studies. Where significant differences between groups were obtained via the analysis of variance or covariance techniques, Dunn's "C" Procedure (initial studies only) or Tukey's W-Procedure was employed to analyze differences between pairs of means.

PROCEDURE FOR REPORTING RESULTS

Efficiency and effectiveness as they relate to visualized instruction means using that type of visual which will be most effective in facilitating student achievement of specifically designated educational objectives. It is reasonable to assume that if two or more types of visuals are equally effective in increasing student achievement, then in terms of time, talents, and funds the least expensive type should be used. It is not justifiable to produce expensive visualization when less costly material has proved to be equally effective. Consequently, all analyses in this report are made in terms of instructional effectiveness, economy, and simplicity of production: that is, the type of visual identified as being most effective in facilitating student achievement on the different criterion measures is the one possessing the most favorable overall relationship of instructional benefit (capacity to increase most efficiently student achievement of specific educational objectives) to cost. For example, if in an experiment three visualized treatments--the line drawing presentation (b&w), the detailed, shaded drawing presentation (b&w), the detailed, shaded drawing presentation (b&w), and the heart model presentation (color)--are all significantly more effective than the oral presentation without visuals

of the heart on a specific criterion measure, the recommendation would be to use the simple line presentation, since this type of visual can be produced most economically. If the results of a study indicate that the oral or verbal instruction without visuals of the heart is as effective as the visualized treatments for a specific educational objective, the oral or verbal instruction alone would be recommended as the most efficient way of transmitting that specific type of information to the student.

SPECIFIC CONCLUSIONS

The following conclusions have been developed from the studies conducted to date. These conclusions provide important guidelines that need to be considered in the development and production of visual materials intended for instructional purposes.

1. The use of visuals specifically designed to complement oral and printed instruction does not automatically improve student achievement. For certain types of educational objectives, oral and printed instruction without visualization is as effective as visually complemented instruction. For other types of educational objectives the use of visuals designed to complement a particular instructional method and to facilitate achievement of a specific educational objective will increase student achievement of that objective.

2. All types of visuals are not equally effective in facilitating student achievement of different educational objectives. The type of visual illustration most effective in transmitting information is dependent upon the type of information to be transmitted.

3. The method by which students receive their visualized instruction (television, slides, programmed instruction) determines the type of visual that will be most efficient in facilitating student achievement of specific educational objectives. Identical visual illustrations are not equally effective when used for externally paced and self-paced instruction.

4. The effectiveness of a particular type of visual in promoting student achievement of a specific educational objective depends on the amount of time students are permitted to interact with the visualized instruction.

5. For students in different grade levels, the same visuals are not equally effective in increasing achievement of identical educational objectives.

6. For specific students and for specific educational objectives, the use of color in certain types of visuals appears to be an important instructional variable in improving student achievement. For other educational objectives, however, the added cost of color may not be justified from the instructional effectiveness viewpoint.

7. In general, for high school students for whom slides are used to complement oral instruction, differential effects attributed to various visualized treatments on immediate retention tests disappear on delayed retention tests.

8. Student perceptions of the value of different types of visual illustrations are not valid assessments of their instructional effectiveness; that is, aesthetically pleasing visuals may be deceptive in their instructional value.

9. The realism continuum for visual illustrations is not an effective predictor of learning efficiency for all types of educational objectives when the visualized instruction is presented via television, slides, programmed instruction, and textbook formats. An increase in the amount of realistic detail contained in an illustration will not produce a corresponding increase in the amount of information a student will assimilate from it.

10. The use of questions to focus student attention on the relevant visual learning cues in the more realistic illustrations used to complement externally paced and self-paced instruction is not an effective technique for improving the instructional potential of the illustrations.

11. Boys and girls in the same grade level (high school) learn equally well from identical types of visual illustrations when they are used to complement oral instruction.

12. Identical visual illustrations are not equally effective in facilitating the achievement of students possessing different levels of entering behavior (prior knowledge in a content area).

13. Merely increasing the size of instructional illustrations by projecting them on larger viewing areas does not automatically improve their effectiveness in facilitating student achievement.

Following is a list of studies which have been conducted in this program of systematic evaluation. The results from these studies have been summarized in the following text.

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